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The Metal Carbonyls: PROFESSOR ARTHUR A. BLANCHARD 311

Obituary:
William Francis Ganong: DR. FRANCES GRACE SMITH and DR. HELEN A. CHOATE. *Deaths and Memorials* 317

Scientific Events:
Buhl Foundation Grant to the University of Pittsburgh; The Bermuda Biological Station for Research; The Harvard School of Dental Medicine; The Science Clubs of America; The American Chemical Society; The Scientific Conference in London; Honorary Degrees Conferred at the Fiftieth Anniversary of the University of Chicago 319

Scientific Notes and News 322

Discussion:
The Effectiveness of Equimolar Quantities of Various Cardiac Glycosides: PROFESSOR MAURICE B. VISSCHER and DR. JOHN S. LADUE. *A Note on Szent-Györgyi's "Toward a New Biochemistry":* PROFESSOR EUGENE W. PIKE and PROFESSOR F. H. PIKE. *One Source of Clay Balls:* DR. GEORGE M. ROBERTSON. *A Florida White Blackberry:* DR. W. A. MURRILL. *An Analysis of the Major Interests of the Members of the Botanical Society of America:* PROFESSOR OSWALD TIPPO 324

Scientific Books:
Physical Chemistry: PROFESSOR VICTOR K. LAMER. *Kinetic Theory of Gases:* DR. W. F. G. SWANN 327

Special Articles:
Isolation of the Viruses of Western Equine and St. Louis Encephalitis, from Culex Tarsalis Mosquitoes: DR. WILLIAM MCD. HAMMON and OTHERS. *Diagnosis of Epidemic Encephalitis by Complement-Fixation Test:* DR. J. CASALS and DR. R. PALACIOS. *Fluorescence of Harderian Glands in Mice of Cancer-Susceptible and Cancer-Resistant Strains:* DR. L. C. STRONG and DR. F. H. J. FIGGE 328

Scientific Apparatus and Laboratory Methods:
A New Digestion Tube: DR. JOSEPH BENOTTI, DR. NORBERT BENOTTI and DR. ETHAN ALLAN BROWN. *A Technique for Continuous or Intermittent Observation of the Contractile Vacuoles of Paramecium:* DR. JAMES SUMNER LEE 331

Science News 10

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THE METAL CARBONYLS[1,2]

By Professor ARTHUR A. BLANCHARD

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THIS meeting is to do honor to a man who was a great scientist, who was later, also, a great administrator, and who, when he reached the age when he could surrender his administrative duties and could enjoy the leisure and rest which he had so fully earned, chose to devote his great energy to the cause of the orderly development of the science of chemistry he loved. Edgar Fahs Smith exemplified the most truly scientific attitude towards chemistry. He championed the importance of accurate finding and recording of facts, and he encouraged the use of theories only as they helped to clarify and classify the facts. A favorite remark of his was to the effect that theories come and theories go, but facts live on forever.

It is, I think, entirely fitting that I should do honor to Professor Smith in telling you the facts about an unusual class of substances, the metal carbonyls, in which I have taken a particular interest, and to show how certain generalizations have helped to some extent to classify and define the relationship among the carbonyls.

NICKEL CARBONYL

Nickel carbonyl was discovered by Mond in 1890, and iron pentacarbonyl was discovered shortly thereafter. These strange substances were a challenge to

[1] Edgar Fahs Smith Memorial Lecture at the University of Pennsylvania May 23, 1941.

[2] Fairly complete literature references may be found in *Chemical Reviews,* 21: 3, 1937, and 26: 409, 1940.

the intelligence of chemists, for, except for the law of definite proportion, they violated every generalization known to chemists at that time.

Nickel carbonyl is formed by the direct combination of carbon monoxide with metallic nickel. Spongy nickel, freshly prepared by gently heating nickel formate in hydrogen, will at room temperature take on carbon monoxide greedily with the formation of nickel carbonyl, $Ni(CO)_4$. On the other hand, compact nickel which has been in contact with the air will not react perceptibly with carbon monoxide. It is this fact which explains why the carbonyls were not discovered earlier.

Nickel carbonyl is a water-white, very mobile and very volatile liquid. It has about the same volatility as ethyl ether, and since inhaling traces of its vapors causes death or incurable impairment of the nerves and the vital organs, it should never be handled except with extreme caution.

Nickel carbonyl forms at room temperature; it also dissociates at moderate temperatures. It is interesting to observe a delivery tube in the open laboratory through which carbon monoxide laden with nickel carbonyl vapor is passing. A thin layer of metallic nickel may deposit on the inside of the tube as a brilliant mirror. Perhaps soon the load of nickel carbonyl vapor may fall off and nearly pure carbon monoxide will be passing. In such a case the black mirror will appear to evaporate.

Nickel carbonyl meets the definitions of a chemical compound. Nickel and carbon monoxide unite in definite proportions and the physical properties of the compound are totally different from the properties of either nickel or carbon monoxide. Yet chemically nickel carbonyl behaves like uncombined nickel on the one hand and like uncombined carbon monoxide on the other hand.

Chlorine and bromine react instantly and quantitatively with nickel carbonyl, forming nickel halide, and all the carbon monoxide is set free. Iodine, sulfur and oxygen react similarly, although not quite so decisively. On the other hand, when nickel carbonyl is inhaled and gets into the blood stream, carbon monoxide instantly combines with the hemoglobin and free nickel is left. It is, in fact, this colloidal nickel in the blood which is so destructive. With Grignard reagents nickel carbonyl reacts instantly with a precipitation of black nickel and the formation of the compounds that would be expected from the reaction of carbon monoxide and Grignard reagent. Nickel carbonyl is insoluble in water but generally soluble in all proportions in organic solvents. It is unattacked by dilute acids and alkalies.

Volatile Carbonyls

The description of the method of formation and of the chemical and physical properties of nickel carbonyl could be applied with only minor modifications to all the metal carbonyls.

The closest analogy to the type of chemical combination existing in the carbonyls is shown by hydrates, which dissociate easily into water and anhydrous salts.

To-day we have quite an impressive list of volatile carbonyls, as shown in Table 1; the volatility is sufficient for molecular weight determinations to be made by the vapor density method at temperatures generally below 100° centigrade.

TABLE 1

Volatile Carbonyls

Compound	Vapor pressure mm	begins to decompose at °C
$Ni(CO)_4$	261 at 15° C	60
$Fe(CO)_5$	15 at 25° C	150
$Ru(CO)_5$	Very volatile	−15
$Cr(CO)_6$	1.0 at 48° C	130
$Mo(CO)_6$	2.3 at 55° C	150
$W(CO)_6$	1.2 at 67° C	150
$Co(CO)_3NO$	56 at 16° C	$<100°$
$Fe(CO)_2(NO)_2$	4.5 at 0° C	$<50°$
$Co(CO)_4H$	Very volatile	−33°
$Fe(CO)_4H_2$	11 at −10° C	$<-33°$
$Re(CO)_5Cl$	sublimes at $<100°$ C	$>100°$

Importance of the Property of Volatility

The property of volatility was one of the first of the properties of matter to be recognized. In the interesting old prints taken from the time of the alchemists we always find the alembic (or still) prominently displayed, thus showing the importance attributed to the property of volatility by the earliest scientists.

To-day the enthusiasm for the more recently recognized properties of matter is so great that I believe that the simple but important property of volatility is too much neglected. I refer to such properties as x-ray diffraction, absorption and emission spectra (both x-ray and optical), electron diffraction, magnetic susceptibility, dielectric constant, Raman spectrum and, perhaps the newest of all, resonance, which in fact is not a property at all but rather an imaginary condition remotely related to those properties that can be measured experimentally.

Volatility signifies lack of cohesion between molecules. There is really little fundamental difference between chemical affinity and cohesion. We are accustomed rather arbitrarily to regard the phenomenon as due to chemical affinity when we find definite proportion, and simply as due to cohesion when the proportions are variable. But both chemical affinity and cohesion are due to the same cause, namely, the field of atoms and molecules and ultimately the field of the nucleus and electrons within the atom.

With the inert gases the tremendous fields of the nucleus and electrons almost completely neutralize each other or, in other words, the lines of force are

completely closed within the atom, and neither cohesion nor chemical affinity are manifest to any marked extent. The atoms of all other elements possess external fields. Where definite groups of atoms can form in which the fields of the different atoms are mutually neutralized, there is little cohesion between the molecules and the compounds are volatile. Thus when we try to study the nature of valence and chemical affinity among the volatile carbonyls the problem is simplified in that all the forces are self-contained within the molecule.

VALENCE AND EFFECTIVE ATOMIC NUMBER

The concept of valence was first introduced to clarify the distinction between atomic and equivalent weights, and at that time no cognizance was taken of the polarity of valence. The knowledge of the hydrocarbons rendered the whole number concept of valence untenable without the employment of new postulates of molecular structure. The development of electrochemistry necessitated the assignment of polarity to valence and thereupon arose the contradictions between polar and non-polar valence which seemed impossible of reconciliation until after the postulates of the electronic constitution of atoms had been introduced. In 1916 G. N. Lewis offered the seemingly absurd suggestion that pairs of electrons could at the same time fill positions in the outer electron shells of two atoms. Atoms are prone to gain or lose electrons until the number in the outer shell or valence layer is eight. Langmuir in 1919 contributed largely in clarifying this "octet" theory of valence. C. R. Bury in 1921 extended this theory to the heavier elements, and showed more specifically how the inert gases served as the fixed reference points of the theory, but how the elements in the mid-parts of the long periods might possess variable atom kernels.

Later Sidgwick, in the course of the study of complex ions, introduced the term "Effective Atomic Number" (E.A.N.) to denote the total number of electrons, both shared and unshared, possessed by an atom. The electronic valence theory as developed by Lewis, Langmuir and Bury may be simply stated in terms of E.A.N. All elements tend to enter the state of combination in such a way as to make the E.A.N. coincide with that of an inert gas.

If this rule is applied to the volatile carbonyls, it is found that in each case the E.A.N. of the central atom is that of an inert gas if in counting the E.A.N. we adopt the reasonable postulates that each carbon monoxide molecule donates two electrons, each nitric oxide molecule donates two electrons and transfers one electron, each hydrogen atom donates one electron and each chlorine atom withdraws one electron to acquire its own octet and then donates or shares two of its octet.

TABLE 2

EFFECTIVE ATOMIC NUMBERS

BH_3CO	5 + 3 + 2	10	Ne
$Ni(CO)_4$	28 + 8	36	Kr
$Fe(CO)_5$	26 + 10	36	Kr
$Ru(CO)_5$	44 + 10	54	Xe
$Cr(CO)_6$	24 + 12	36	Kr
$Mo(CO)_6$	42 + 12	54	Xe
$W(CO)_6$	74 + 12	86	Rn
$Co(CO)_3(NO)$	27 + 6 + 3	36	Kr
$Fe(CO)_2(NO)_2$	26 + 4 + 6	36	Kr
$Co(CO)_4H$	27 + 8 + 1	36	Kr
$Fe(CO)_4H_2$	26 + 8 + 2	36	Kr
$Re(CO)_5Cl$	75 + 10 − 1 + 2	86	Rn

It is noteworthy that nickel carbonyl, $Ni(CO)_4$, which is the most volatile of all the carbonyls, is the only carbonyl of nickel.

If monomeric tetracarbonyls of iron and cobalt were to exist, the E.A.N. would not be 36. But the modifications of tetracarbonyls, $Fe(CO)_2(NO)_2$, $Fe(CO)_4H_2$ $Co(CO)_3(NO)$ and $Co(CO)_4H$, all of which are known and are very volatile, do show an E.A.N. of 36 for the central atom. Furthermore, iron and cobalt are prone to form polymeric tetracarbonyls, $[Fe(CO)_4]_3$ and $[Co(CO)_4]_2$, which are only very slightly, if at all, volatile. To iron and cobalt in these polymers we may easily ascribe the E.A.N. of 36 by properly placing the shared electrons which bind the polymers together.

A complete list of the polymeric carbonyls is given in table 3.

TABLE 3

POLYMERIC CARBONYLS

$Fe_2(CO)_9$
$[Fe(CO)_4]_3$
$[Co(CO)_4]_2$
$[Co(CO)_3]_4$
$Ru_2(CO)_9$
$[Ru(CO)_4]_n$

Of these, the ennea carbonyls, $Fe_2(CO)_9$ and $Ru_2(CO)_9$, and the tetracarbonyl $[Co(CO)_4]_2$ may be sublimed without decomposition, but all the molecular weights are determined only by the freezing point lowering method in organic solvents.

METAL CARBONYLS AS COORDINATION COMPOUNDS

It is interesting to note that Albert Werner's system of coordination was first proposed at about the time of the discovery of nickel and iron carbonyls. However, it was some time before it was realized that the carbonyls fitted into this system. The earlier grotesque attempt to assign a structure to the carbonyls would often postulate ring structures with the metal atom a member of the ring. However, when the coordination system began to assume the stature of a real theory, through the application to it, notably by Sidgwick, of the newly developed ideas of the electronic structure of matter, it became apparent that the carbonyls belonged properly in the coordination theory with the metal atom in the center of the co-

ordinate group. A notable difference between the carbonyls and all other coordination complexes remained, however, in that the valence (electrovalence) of the metal atom of the carbonyls is zero, whereas always the valence of the metal atom in other complexes is a positive number.

The central position of the metal-atom in the carbonyl complex is supported by recent studies of electron diffraction, which indicate that: in the compounds with four addenda the four groups are situated at the corners of a tetrahedron surrounding the metal atom; in the penta carbonyls the structure is that of a trigonal bipyramid and in the hexacarbonyls the structure is octahedral; the atom arrangement M–C–O and M–N–O form straight lines, the hydrogen atoms lie at the end of the chain M–C–O–H; and the bond distances are such as to be in harmony with a condition of resonance between the structures

I	M:C:::O:	M:N:::O:	M:C:::O:H
II	M::C::O::	M::N::O::	M::N::$\ddot{O}$:H

The extreme resemblance of carbon monoxide and nitric oxide in physical properties is taken to indicate a similarity in constitution. The most commonly accepted electronic structure of carbon monoxide is shown in the formula

:C:::O:

Nitric oxide has one more electron, which is somehow tucked away in the molecule without a profound effect on the physical properties. When coordination of carbon monoxide with a metal atom takes place, the lone pair on the carbon atom enters the coordination layer of the metal atom and thus the E.A.N. of the metal is increased by two. When nitric oxide coordinates, the lone pair of the nitrogen atom enters the coordination layer of the metal atom and the extra electron of the nitric oxide is transferred completely and thus the E.A.N. of the metal is increased by three. In the resonating structures it is to be noted that two of the electrons of the double bond between the metal and carbonyl group or the metal and the nitrosyl group came from the metal so that the E.A.N. of the metal and, in fact, of the carbon oxygen and nitrogen, remains unchanged by the resonance.

When, a moment ago, we spoke of zero valence in the carbonyls we spoke in rather vague terms although we would probably be understood in the sense that was intended. Whenever water molecules (in hydrates), cyanide ions (in complex ions), carbon monoxide molecules (in carbonyls), coordinate, the coordinating electrons are counted as still belonging exclusively to the addenda when the polar valence of the central atom is counted and thus the valence becomes the difference between the atomic number (nuclear charge) and the number of electrons inside of the coordinate layer. According to this method of counting, the valence of the metal would be zero in $Ni(CO)_4$, $Fe(CO)_5$, $Cr(CO)_6$, $Mo(CO)_6$, $W(CO)_6$, but it would be minus one in $Co(CO)_3NO$ and $Co(CO)_4H$ and minus two in $Fe(CO)_2(NO)_2$ and $Fe(CO)_4H_2$.

No one should disagree with the appraisal of such valences as the height of absurdity. We have simply illustrated the seeming absurdities we reach when we give the result of our own counting of valence if we do not very exactly specify our method of counting.

Non-Volatile Carbonyls

In addition to the volatile carbonyls there are a great many complex compounds or salts in which carbon monoxide and nitric oxide are present and obviously bound as coordinated addenda in the same manner as in the volatile carbonyls. Table 4 contains a list of some of the more important of these where X stands for a halogen atom.

TABLE 4

Non-Volatile Carbonyl and Nitrosyl Complexes

$CuX \cdot CO$	$AuCl \cdot CO$
$CuX_2 \cdot NO$	$FeI \cdot 2NO$
$RuX_2 \cdot 2CO$	$CoI \cdot 2NO$
$RuBr \cdot CO$	$Ag_2SO_4 \cdot CO$
$PdCl_2 \cdot CO$	$RhCl_2 \cdot RhO \cdot 3CO$
$OsX_2 \cdot 3CO$	$RhCl_2 \cdot RhO \cdot 3NO$
$IrCl_2 \cdot 2CO$	$FeSO_4 \cdot NO$
$PtCl_2 \cdot CO$	$CO \cdot Hg(OC_2H_5)(COOCH_3)$
$2PtCl_2 \cdot 3CO$	

Some of these compounds may be sublimed without decomposition but none have an appreciable volatility at ordinary temperatures. There is no apparent dependence of these compounds upon the effective atomic number, but since these compounds are not volatile and the molecular weight of few of them has been determined, it is impossible to draw definite conclusions whether the E.A.N. is or is not a dominating factor in their existence.

Complex Ions and Effective Atomic Number

At all events the effective atomic number is very clearly a dominant influence in the formation of the volatile carbonyls, and also from the other point of view the regularities observed among the volatile carbonyls confirms a wider potency of the influence of the E.A.N. than had been suspected from the composition of the simpler compounds of the transition elements. Elements within three places of the inert gases are conceded to acquire the electron structure of the inert gases, but the elements in the middle parts of the long periods have been generally conceded to acquire polar valence through a transfer of electrons into incomplete inner layers, leaving generally two or three electrons only in the valence layer.

Complete loss of these valence electrons has gen-

erally been regarded as the explanation of polar valence in such ions as are commonly formulated as Fe^{++}, Fe^{+++}, Mn^{++}, Cr^{+++}, Co^{++}, Ni^{++}, etc., and little evidence has been apparent that the effective atomic number exerts any influence in forming compounds of the transition elements.

But with the evidence of the volatile carbonyls and in view of the fact that carbon monoxide and nitric oxide enter the composition of many complex ions it seemed fitting to reexamine the list of complex ions to see if any influence of the E.A.N. could be traced. I believe that the evidence presented in Tables 5–9 will be quite convincing that there is such an influence.

There is a good deal of similarity between volatility and ionization. In volatile substances the field is self-contained within the molecule and the lack of external field accounts for the lack of cohesion between the molecules. With charged ions there is a great external field and there can be no chance of volatility outside the confines of the solution. But within the solution ions may exist when the electrostatic field is uniform, that is, when the charge is symmetrically distributed over the ion.

Nickel atoms are usually pictured as forming ions through the loss of electrons:

$$Ni \rightarrow Ni^{++} + 2\,\theta.$$

The fact that bare Ni^{++} ions do not exist in more than the most infinitesimal concentrations, if at all, does not seem to bother the authors of text-books. The only excuse for writing Ni^{++}—and it is seldom apparent that the authors realize any need for an excuse—is that the number n of water molecules in the hydrate $Ni \cdot nH_2O^{++}$ is unknown. It ought to be apparent from the knowledge of complex ions such as

$$Ni \cdot 4NH_3^{++}$$
$$Ni \cdot (CN)_4^{--}$$

that the ion Ni^{++} can not exist in water without surrounding itself with coordinating H_2O molecules. If the coordinating groups

$$\begin{matrix} & H & \\ & \cdot\cdot & \\ :N: & & H \\ & \cdot\cdot & \\ & H & \end{matrix} \quad \text{and} \quad :C:::N:$$

are joined to the nickelous ion by means of the lone pairs it is obvious that each addendum adds 2 to the E.A.N. which thus becomes

$$28 - 2 + 8 = 34.$$

Obviously, the coordinating shell of eight electrons between the positive kernel of the Ni atom and the positive kernels of the N or C atoms imparts a certain stability to the structure. These complex nickelous ions are moderately stable but let us compare their stability with that of the cobaltic complex ions.

$$Co \rightarrow Co^{+++} + 3\,\theta$$
$$Co^{+++} + 6\,NH_3 \rightarrow Co \cdot 6\,NH_3^{+++}$$
$$CO^{+++} + CN^- \rightarrow Co(CN)_6^{---}$$

These cobaltic complexes are extraordinarily stable and once formed they are broken down only by very strenuous chemical treatment. In them the E.A.N. of cobalt is

$$27 - 3 + 12 = 36.$$

It might of course be accidental, and due to some other cause, that in these two cases the complex with the E.A.N. of krypton is much more stable, but let us proceed to see how generally such a relation holds.

Complexes of Iron

Of the two cyanide complexes of iron the ferricyanide (E.A.N. = 37) is the less stable and it tends to go over to the ferrocyanide (E.A.N. 36). In Table 5 are listed several of the substituted cyanide complexes of iron where M represents a univalent alkali metal.

TABLE 5

Complexes of Iron

$M_4[Fe(CN)_6]$	26 − 2 + 12	36
$M_3[Fe(CN)_6]$	26 − 3 + 12	35
$M_2[Fe(CN)_5NO]$	26 − 2 + 12	36
$M_3[Fe(CN)_5NH_3]$	26 − 2 + 12	36
$M_3[Fe(CN)_5NO]$	26 − 1 + 12	37
$M_2[Fe(CO)_4]$	26 + 2 + 8	36

Treatment of either the ferrocyanide or ferricyanide with hot concentrated nitric acid yields the fairly stable nitro prusside complex, E.A.N. 36, and sodium nitro prusside can be crystallized from the solution. If this complex is treated with ammonia, the nitric oxide is substituted by ammonia $M_2[Fe(CN)_5NO] + 3\,NH_3 + H_2O \rightarrow NH_4M_2[Fe(CN)_5NH_3] + NH_4NO_2$ and the E.A.N. in the new complex is still 36.

But if the ammonia-substituted complex is treated with NO in acidified solution the freely running reaction $HC_2H_3O_2 + M_3[Fe(CN)_5NH_3] + NO \rightarrow M_3[Fe(CN)_5NO] + NH_4C_2H_3O_2$ gives rise to a different nitro prusside complex in which the E.A.N. is 37. But this complex is very unstable and it spontaneously changes into the ordinary nitro prusside within a short time.

Complexes of Cobalt

Contrasted with the cyanide complexes of iron, the cobaltocyanide complex (E.A.N. 37) is the unstable compound of cobalt and this has a very strong tendency to go over into the cobalticyanide.

TABLE 6

Complexes of Cobalt

$M_3[Co(CN)_6]$	27 − 3 + 12	36
$M_4[Co(CN)_6]$	27 − 2 + 12	37
$M_3[Co(CN)_5CO]$	27 − 2 + 12	37
$[Co(NH_3)_6]X_3$	27 − 3 + 12	36
$M[Co(CO)_4]$	27 + 1 + 8	36

In the preparation of the carbonyl substituted double cyanide Manchot and Gall took extreme precaution to prevent possible oxidation to the cobaltic state and hence no chance was given to form the compound $M_2[Co(CN)_5CO]$ in which the E.A.N. would be 36. In our own laboratories all attempts to prepare either this complex or $M[Co(CN)_5NO]$ have failed, but invariably some other compounds with E.A.N. of 36 have appeared, either $M[Co(CO)_4]$ or $M_3[Co(CN)_6]$.

Complexes of Nickel

In all the complex cyanides of nickel the coordination number is four. No complex compound of the formula $M_2[Ni(CN)_6]$ in which the E.A.N. would be 36 has been prepared and it is hard to see why such a compound would not be stable.

TABLE 7

Complexes of Nickel

$M_2[Ni(CN)_4]$	28 − 2 + 8	34
$M_4[Ni(CN)_4]$*	28 + 0 + 8	36
$M_2[Ni(CN)_3NO]$	28 + 0 + 8	36
$Ni(CO)_4$		36

* W. M. Burgess: private advices.

The complex cyanide $M_2Ni(CN)_4$ obtained by treating salts of divalent nickel with excess alkali cyanide is not particularly stable. When the coordination number is four it is only possible for the nickel to show the E.A.N. of krypton when the nickel has the unexpected polar valence of zero. And we find that the complexes $[Ni(CN)_4]^{----}$ and $[Ni(CN)_3NO]^{--}$ exist as well as nickel carbonyl in which the polar valence is zero.

TABLE 8

Complexes of Manganese

$M_3[Mn(CN)_6]$	25 − 3 + 12	34
$M_4[Mn(CN)_6]$	25 − 2 + 12	35
$M_5[Mn(CN)_6]$	25 − 1 + 12	36
$M_3[Mn(CN)_5NO]$	25 − 1 + 12	36

The ordinary double cyanides obtained from salts of divalent and trivalent manganese and excess of alkali cyanide are not particularly stable, but the trend towards the E.A.N. of 36 is shown in the formation of complexes of monovalent manganese $[Mn(CN)_6]^{-----}$ and $[Mn(CN)_5NO]^{---}$. The E.A.N. influence must indeed be compelling to allow the existence of a complex ion with five charges.

Complexes of Chromium

The only complex cyanides of chromium on record are those formed from the common salts of divalent and trivalent chromium and excess of alkali cyanide

$M_3[Cr(CN)_6]$	24 − 3 + 12	33
$M_4[Cr(CN)_6]$	24 − 2 + 12	34

and neither of these are particularly stable.

With the coordination number of six in order to acquire the E.A.N. of krypton, chromium would have to show a polar valence of zero as it does in the hexacarbonyl, and we might look for the complex compounds $M_6[Cr(CN)_6]$, $M_5[Cr(CN)_5CO]$, $M_4[Cr(CN)_5NO]$. With coordination number four we might look for $[Cr(NO)_4]$ and $M_4[Cr(CO)_4]$ and with coordination number eight we might look for $M_4[Cr(CN)_8]$. As a matter of fact, molybdenum and tungsten do show the E.A.N. of xenon and radon, respectively, in the octacyanide complexes.

$M_4[Mo(CN)_8]$	42 − 4 + 16	54
$M_4[W(CN)_8]$	74 − 4 + 16	86

TABLE 9

Complexes of the Platinum Metals

$M_4[Ru(CN)_6]$	44 − 2 + 12	54	Xe
$M_2[Ru(CN)_5NO]$	44 − 2 + 12	54	Xe
$M_2[RuCl_5NO]$	44 − 2 + 12	54	Xe
$M_3Rh(CN)_6$	45 − 3 + 12	54	Xe
$M_2[PdCl_6]$	46 − 4 + 12	54	Xe
$M_2[Pd(CN)_4]$	46 − 2 + 8	52	
$M_2[OsCl_6]$	76 − 4 + 12	84	
$M_3[OsCl_6]$	76 − 3 + 12	85	
$M_2[OsCl_5NO]$	76 − 2 + 12	86	Rn
$M_4[Os(CN)_6]$	76 − 2 + 12	86	Rn
$M_3[Ir(CN)_6]$	77 − 3 + 12	86	Rn
$M_2[PtCl_6]$	78 − 4 + 12	86	Rn
$M_2[PtCl_2(CN)_4]$	78 − 4 + 12	86	Rn
$M_2[Pt(CN)_4]$	78 − 2 + 8	84	

Table 9 presents a representative although not a complete list of the complexes of the platinum metals, and it should be remembered that the discovery of these compounds was essentially accidental, and certainly not as the result of a deliberate attempt to confirm the E.A.N. doctrine. Again we find that the stabilizing effect of a coordinate layer of eight or twelve allows some complexes to exist with E.A.N. not that of an inert gas. But in the main, the tendency to acquire the E.A.N. of xenon and radon is very obvious and is controlling in every instance cited in which nitric oxide enters the complex.

Recent advices from W. C. Fernelius state that he has succeeded in preparing a compound of palladium, $K_4Pd(CN)_4$, in which palladium has the valence of zero and the E.A.N. of xenon. Fernelius applied the method by which Burgess obtained the similar nickel compound $K_4Ni(CN)_4$. A solution of potassium palladocyanide, $K_2Pd(CN)_4$, in liquid ammonia is treated with a solution of potassium in liquid ammonia. A sharp end point is reached both with the nickel and the palladium compound when the deep blue color of the potassium solution ceases to be discharged. It may be noted that when Burgess analyzed his preparation he was so astonished to find the composition $K_4Ni(CN)_4$ that he felt compelled to recheck his analyses before he could believe the existence of a compound in which nickel had a valence of zero. Comparison of this compound with the carbonyls, however, helped greatly to relieve the disbelief. On

the other hand, Fernelius on the basis of Burgess' discovery hoped to prepare $K_4[Pd(CN)_4]$ and his success in doing so must be considered as a strong support of the potency of the effective atomic number.

SUMMARY

When the metal carbonyls were first discovered, their properties were startling because they seemed to violate nearly all the previously recognized generalizations of chemistry. Even to-day the existence of the carbonyls is not particularly emphasized in elementary courses of chemistry because it is rather hard to reconcile them with the first presentations of the generalizations of chemistry. Nevertheless, as the student progresses deeper into the knowledge of chemistry it becomes desirable to include the knowledge of the carbonyls both because they become more comprehensible when viewed in the light of Werner's system of coordination and because they themselves contribute to the comprehension of the Werner theory.

As long ago as 1931, Reiff in his discussion of cobalt nitrosyl carbonyl recognized the correlation between the effective atomic number and the volatility of carbonyls. A more recent study of *charged* Werner coordination complexes, that is, of complex ions, has shown a similar role of the effective atomic number.

We are standing on fairly firm ground when we point out the correlation between E.A.N. and the volatility of the carbonyl complexes and the existence of complex ions. Be it noted that we have made no postulates as to the arrangement of the electrons in quantum levels. In the inert gases the outer principal quantum group is supposed always to contain eight electrons. In the carbonyls and other Werner complexes there is no compelling reason to suppose that the electrons in the coordinating layer, be this layer of eight, ten, twelve or sixteen electrons, are not all at the same energy level.

Although we have confined our discussion almost exclusively to the property of volatility, the carbonyls are very interesting from the standpoint of several other properties, for example, magnetic susceptibility and dielectric constant. Enthusiasts in the interpretation of such properties try to draw conclusions as to the condition of the electrons, sometimes they become so dogmatic as to seem really to believe in the actual existence of the condition they postulate.

As Professor Smith said, "Theories come and theories go, but facts live on forever." The facts of chemistry are so multitudinous that we would be utterly helpless to use them had we not means of correlating them. Any postulates which reach beneath the surface of the directly observable to give a mechanism to correlate the facts are helpful. But a scientist without a sense of humor is pretty hopeless. Who in his right mind can regard as other than absurd the idea that an electron pair can simultaneously occupy positions in two atom shells to make up the supposedly necessary number in each atom? In fact, is not the electron itself a pretty ridiculous figment of the imagination? To be sure, we recognize the electron as a discrete entity with certain very definite properties, but in the light of comparison with any mechanism within our comprehension is not the electron perfectly impossible? By all means let us use a postulate which allows us to make a useful classification of facts, but never let us lose the sense to see how utterly ridiculous the postulate will look to one who has not like ourselves grown attached to it.

We do not expect ever to discover the ultimate reason for things, but we do expect ever to make progress in correlating and classifying the facts which we have already discovered and shall continue to discover. Dogmatic belief in ridiculous postulates retards this progress.

Since the foregoing manuscript was submitted the paper by Hieber and Lagally, *Zeit. Allgem. Anorg. Chem.*, 245: 321, November, 1940, has come to our attention in which the preparation of carbonyls of iridium by Hieber's high pressure technique is described. Non-volatile $[Ir(CO)_3]n$, corresponding to the cobalt tricarbonyl, is the principal product, but there is evidence that compounds corresponding to $[Co(CO)_4]_2$ and the volatile $HCo(CO)_4$ are also formed. A very volatile compound containing iridium is in evidence whenever traces of water or hydrogen are present in the autoclave, and although this compound can not be isolated for analysis it presumably is the carbonyl hydride $HIr(CO)_4$ in which iridium has the E.A.N. (86) of radon.

OBITUARY

WILLIAM FRANCIS GANONG
1864–1941

THE death of William Francis Ganong removes from the field of botany one of its outstanding leaders during the past fifty years. Dr. Ganong, a Canadian of loyalist descent, was born in St. John, New Brunswick, on February 19, 1864, the son of the late James H. and Susan E. Ganong. He was graduated from the University of New Brunswick with the degree of B.A. in 1884 and with that of M.A. in 1886, and in 1887 received his A.B. from Harvard. He obtained his Ph.D. from Munich in 1894, and in 1898 and 1920

was granted the honorary degrees of Ph.D. and LL.D., respectively, by the University of New Brunswick.

Except for a few years of teaching at Harvard his entire academic life was spent at Smith College, Northampton, Massachusetts. Coming in 1894 as the first professor of botany and director of the Botanic Gardens, he built up the department of which he served as head or chairman until his retirement in 1932, when he was appointed professor emeritus. During his service here, the Botanic Gardens were established, and the Lyman Plant House and Burton Hall, the present biology building, were erected. For many years he gave generously of his time to administrative matters.

A man of broad interests, he published in the fields of morphology and ecology, although his primary interest was in physiology. Here he was widely known for his research and the apparatus which he developed for student use. But to those who knew him best he will be remembered primarily as a teacher. Possessed of an enthusiasm which was easily passed on to his students he taught both by precept and example, instilling into their minds the love of honest, thorough work and regard for the truth. His interest in botanical education led to the publication of *The Teaching Botanist,* one of the earliest books in this field now growing in importance. Other books of his were "A Laboratory Course in Plant Physiology," "The Living Plant" and "A Textbook of Botany for Colleges."

He had served as secretary for the Society of Morphology and Physiology and as president of the Botanical Society of America. He was also a corresponding member of the Royal Society of Canada, and in December, 1940, was awarded the Charles Reid Barnes Life Membership by the American Society of Plant Physiologists.

In addition to his work as a botanist he was recognized as an authority on the natural history of New Brunswick. From his early days he had followed this subject with great enthusiasm and during this time had assembled an unusually valuable collection of books, papers, maps and other documents bearing upon New Brunswick history. This collection has been presented to the New Brunswick Museum and has been described as "undoubtedly the most valuable that has yet been offered to the Museum." Of him and his work Dr. J. Clarence Webster, C.M.G., of Schediac has said: "As a worker Dr. Ganong has been characterized by great honesty and accuracy. Regarding New Brunswick he was the greatest authority who ever lived on the subject; its natural history, its settlement, its geology, its Indian life and its general development. As an authority on the cartography of the entire eastern coast of North America, he and Mr. Prowse of Winnipeg are two of the greatest." Dr. Ganong translated and edited Denys' "Natural History of Acadia," LeClerq's "New Relation of Gaspesia" and Champlain's "Voyages to Acadia and New England."

Dr. Ganong was married in 1888 to Jean Murray Carman, of Fredericton, New Brunswick, the sister of Bliss Carman, the well-known Canadian poet. She died in 1920 and he later married Anna Hobbet, of Eagle Grove, Iowa, who with two children, William Francis, Jr., a freshman at Harvard, and Ann, survive him. His death occurred on September 7, at St. John, New Brunswick, after a long illness.

FRANCES GRACE SMITH
HELEN A. CHOATE

SMITH COLLEGE

DEATHS AND MEMORIALS

DR. FRANK BURR MALLORY, since his retirement in 1932 professor emeritus of pathology in the Harvard Medical School, died on September 27 at the age of seventy-eight years. Dr. Mallory joined the staff of the school as assistant in histology in 1890. He was pathologist of the Boston City Hospital from 1908 to 1932, when he became consulting pathologist.

DR. CARROLL MASON SPARROW, professor of physics in the University of Virginia, died suddenly at his home on the evening of August 30. He was sixty-one years old. He had served on the faculty for thirty years.

DR. THOMAS HARDY TALIAFERRO, professor of mathematics and dean of the faculty of the University of Maryland, died on September 25 at the age of seventy years.

DR. ANDREW RICHARD BLISS, JR., professor of pharmacology and dean of the School of Pharmacy of Howard College, Birmingham, Ala., died on August 12 in his fifty-third year.

DR. ELMER SAMUEL IMES, professor and head of the department of physics at Fisk University, Nashville, Tenn., died on Setember 12 at the age of fifty-eight years.

A COPY of the Congressional resolution designating February 11 as "Thomas A. Edison Day" and the pen with which it was signed by President Roosevelt were presented on September 25 to Mrs. Mina Edison Hughes, widow of the inventor, at a dinner, attended by three hundred and fifty persons, which had been arranged by the Chamber of Commerce and Civics of the Oranges and Maplewood, N. J.

SCIENTIFIC EVENTS

BUHL FOUNDATION GRANT TO THE UNIVERSITY OF PITTSBURGH

THE Buhl Foundation of Pittsburgh, Pa., has announced the renewal and enlargement of a grant to the University of Pittsburgh in support of graduate study and a coordinated research program in the departments of chemistry, physics and biology. A fund of $40,000 per year, primarily for research fellowships and supplies, will be available through a five-year period, three fourths of the fund being contributed by the foundation and one fourth by the university. The grant will be administered by a Research Committee consisting of Provost Rufus H. Fitzgerald, Dean Stanton C. Crawford, Dean William T. Root, Dean William S. McEllroy, Dr. Leonard H. Cretcher, Dr. Edward U. Condon, Dr. Davenport Hooker, Dr. Peter Gray, Dr. Elmer Hutchisson and Dr. C. G. King, *chairman*. In the division of biochemistry, major emphasis will be placed upon studies in nutrition, tissue respiration and the chemistry of fats. Specific heats, heats of combustion and heats of dilution will be studied in relation to the molecular structure of sugars, fats and amino acids in the division of physical chemistry. Research involving the use of radioactive tracer elements and spectroscopy will be carried out in cooperation with the department of physics, where additional work will be supported in the field of atomic physics (where a cyclotron is under construction) and in the use of the electron microscope. Three research fellows in the department of biology will study basic problems in embryology, two phases of which (blood formation and the effects of copper) are closely related to work under way in the department of chemistry.

THE BERMUDA BIOLOGICAL STATION FOR RESEARCH

THE buildings and grounds of the Bermuda Biological Station have been leased to the U. S. Government for a period of one year, with privilege of renewal, as a temporary hospital for the construction workers and personnel of the U. S. Base in Bermuda.

Books, scientific equipment and supplies have been placed in storage in St. Georges. The activities of the station, however, will not be suspended since the government aquarium at Flatts has made available its small laboratory and will assist in collecting material and otherwise aiding those who wish to carry on investigations in Bermuda. In fact, a few workers have already made use of these facilities. The aquarium has also offered a portion of its property adjacent to the new museum as a site for a temporary building to accommodate books and for additional laboratory space. At a recent meeting of the trustees of the station it was voted to erect such a building, and plans are now being drawn up.

Special rates to Bermuda for scientific workers are available from the Alcoa Line, which has weekly sailings from New York. Living accommodations are available at Flatts. Investigators who have problems that they may wish to work on in Bermuda should communicate with the Secretary—J. H. Welsh, Biological Laboratories, Harvard University, Cambridge, Mass.

THE HARVARD SCHOOL OF DENTAL MEDICINE

DR. LEROY M. S. MINER, dean of the Harvard Dental School, has announced the opening on September 23 of the new "Harvard School of Dental Medicine," with nine carefully selected students from widely separated parts of the country composing the first-year class. The new school was made possible by an endowment of $1,500,000, mainly derived from gifts of the Carnegie, Rockefeller and Markle Foundations. For the present the maximum number of students to be accepted under the plan of instruction in any one class is set at fifteen. The Harvard Dental School will continue its present course for three years more, until members of the present second-year class are graduated. Dean Miner has made the following statement:

> The opening of the new school marks the beginning of an important experiment in American dental education. The trend in dental training in the last twenty-five years has been towards increased biological study of the causes of diseases of the teeth and closer cooperation with medicine. Students in the new school will be occupied for the majority of five calendar years in a combined course of dentistry and medicine, and at the end of that time successful candidates will receive both the M.D. and D.M.D. degrees. The student will receive the basic training in medicine required of all physicians, without sacrificing the essential training in the restorative and reparative techniques of dentistry which are all important. In addition, by the combined work which he will perform, we hope he will be well equipped to carry on further study on the causes of dental disease and its prevention.

The faculty of the new school will be composed, in addition to Dean Burwell, of the Medical School, who is chairman of the Committee on Instruction, of thirteen men who are now serving the Harvard Dental School with distinction, and the following three men who have been called from the outside to work in the development of the new program. These men are: Joseph W. Ferrebee, M.D., associate professor of dental medicine, formerly of the College of Physicians and Surgeons, New York; Dr. Martin L. Deakins, formerly of the University of Rochester School of Medicine and Dentistry, and Charles M. Waldo, D.D.S., assistant professor of orthodontics, formerly of the University of Michigan School of Dentistry.

The new laboratory of dental medicine, directed by Dr. Joseph W. Ferrebee, is an important step forward in the field of investigation in problems incident to dental medicine, and will be integrated usefully with the several leading hospitals associated with the professional education at Harvard. Furthermore, carrying out on a larger scale activities already instituted at the Harvard Dental School, Dr. Paul E. Boyle is in charge of the laboratory of oral pathology, closely associated physically and in function with the department of pathology at the Harvard Medical School, directed by Dr. S. B. Wolbach. With these two laboratories as centers, opportunities will be provided for research workers, and for teachers, and, also, students in clinical dentistry will be afforded an insight into fundamental dental problems not heretofore possible.

THE SCIENCE CLUBS OF AMERICA

SCIENCE SERVICE reports in a press bulletin that it has joined the American Institute of the City of New York, an institution chartered in 1828, in developing the science clubs movement. Science Service will sponsor the Science Clubs of America as a national science club movement. The American Institute will continue to foster junior science clubs and related activities in the metropolitan area of New York City and in the State of New York.

An advisory committee on Science Clubs of America, representing jointly the American Institute and Science Service, is being formed.

In developing this broad science clubs movement, there will be enlisted the enthusiasm, support and participation of newspapers, museums, schools and other scientific and educational institutions, including professional scientific societies and industrial organizations.

In various regions there will be developed additional "science centers," which, on a regional or local basis, will further coordinate and aid the science clubs in their vicinities as a supplement to the national organization.

The new plan has been announced by Dr. H. C. Parmelee, president of the American Institute, and Watson Davis, director of Science Service, in simultaneous communications to sponsors of existing science clubs. The statement made by Dr. Parmelee reads:

> About 14 years ago, when The American Institute was rounding out a hundred years of service to American industry, the leaders of this century-old organization launched a wholly modern activity that was, nevertheless, in harmony with the oldest and finest traditions of the institute. They started a program to encourage and develop an interest in science among the youth of the metropolitan area of New York City. That movement shortly resulted in the organization of about two hundred Junior Science Clubs, a Junior Science Fair and a Junior Science Congress.
>
> Attracted by the success of the local movement, and believing firmly in the value of scientific knowledge and training among the youth of the country, the Westinghouse Electric and Manufacturing Company placed at the disposal of the institute means for extending the Junior Science Club movement and related activities throughout the United States. The program met with unparalleled success and resulted in the organization of over eight hundred clubs. Indeed the movement expanded beyond the present capacity of the institute to service all the clubs and foster their related activities.
>
> At this juncture Science Service, an institution for the popularization of science, with headquarters in Washington, D. C., and excellent national contacts and affiliations, proposed to the institute a division of responsibility in the Junior Science Program.
>
> Speaking for The American Institute, I commend the joint plan as a step in the achievement of common objectives; and I believe that both working together can accomplish more than each separately.

Mr. Davis said:

> The work that you are doing in inspiring and directing a science club is one of the great services to American youth. In order that we may have a continuance of our democratic civilization based on scientific principles, it is essential that such endeavors as yours shall be given the fullest possible support and that other leaders of youth follow your example.
>
> It is in this spirit that Science Service, the institution for the popularization of science, joins its forces with those of The American Institute in continuing, extending and developing the science club movement.

THE AMERICAN CHEMICAL SOCIETY

AN increase in the membership of the American Chemical Society during the past year to a total of 28,525 is reported by Dr. Charles L. Parsons, secretary of the society.

A new local section, to be known as the Binghamton Section with headquarters at Binghamton, N. Y., has been organized, bringing the number of sections throughout the country to ninety-four. The next semi-annual meeting will be held in Memphis, Tenn., in April, 1942.

Walter A. Schmidt, of the Western Precipitation Company, Los Angeles, Calif., has been named to the Council Policy Committee for a term of three years beginning January, 1942.

Associate editors to four of the society's publications have been chosen as follows:

Journal of American Chemical Society: Professor Frederick G. Keyes, of the Massachusetts Institute of Technology; Professor N. Howell Furman, of Princeton University; Dr. Paul H. Emmett, of the Johns Hopkins University.

Technological Autographs: Thomas Chilton, of E. I. du Pont de Nemours and Company, Wilmington, Del.; Mr. Schmidt; Dr. E. R. Weidlein, director of the Mellon Institute of Industrial Research, Pittsburgh, Pa.

Journal of Physical Chemistry: Dr. Leason H. Adams, director of the Geophysical Laboratory, Carnegie Institution of Washington; Professor R. S. Livingston, of the University of Minnesota.

Chemical Reviews: Norman D. Scott, of E. I. du Pont de Nemours and Company, Sanborn, N. Y.; Professor Warren C. Johnson, of the University of Chicago.

Dr. B. L. Clarke, of the Bell Telephone Laboratories, New York City, and Thomas R. Cunningham, of the Union Carbide and Carbon Company, Niagara Falls, N. Y., have been named to the advisory board of the analytical edition of *Industrial and Engineering Chemistry.*

THE SCIENTIFIC CONFERENCE IN LONDON

THE International Conference arranged by the British Association for the Advancement of Science opened in London on September 26, with a message from the Prime Minister, and there was read later a message from King George VI. John G. Winant, United States Ambassador, presided over the first session, and later sessions were presided over by the Soviet Ambassador, Ivan Maisky, and Dr. Eduard Beneš, president of the Czech Government in exile.

The meeting was opened by Sir Richard Gregory, president of the British Association, editor of *Nature* from 1919 to 1939, who at the concluding session presented a seven-point charter of scientific principles which was adopted. As cabled to *The New York Times,* it reads:

(1) Liberty to learn, the opportunity to teach and the power to understand are necessary for the extension of knowledge and we, as men of science, maintain that they can not be sacrificed without the degradation of human life.

(2) Communities depend for their existence, survival, knowledge and advancement on the knowledge of themselves and of the properties of things in the world around them.

(3) All nations and all classes of society have contributed to the knowledge and utilization of natural resources and to the understanding of the influence they exercise on human development.

(4) The basic principles of science depend on independence combined with cooperation and are influenced by the progressive needs of humanity.

(5) Men of science are among the trustees of each generation's inheritance of natural knowledge. They are bound, therefore, to foster and increase that heritage by faithful guardianship and service to high ideals.

(6) All groups of scientific workers are united in the fellowship of the commonwealth of science which has the world for its province and the discovery of truth as the highest aim.

(7) The pursuit of scientific inquiry demands complete intellectual freedom and unrestricted international exchange of knowledge and can only flourish through the unfettered development of civilized life.

HONORARY DEGREES CONFERRED AT THE FIFTIETH ANNIVERSARY OF THE UNIVERSITY OF CHICAGO

THE scientific papers in the symposia on "New Frontiers in Education and Research," given on the occasion of the celebration of the fiftieth anniversary of the University of Chicago held in cooperation with the American Association for the Advancement of Science, were followed by a convocation on September 29 at which honorary degrees were conferred. Those in science, according to the advance announcement, were as follows:

Charles E. Allen, professor of botany, the University of Wisconsin, discoverer of sex chromosomes in plants.

Charles H. Best, professor and chairman of the physiology department at the University of Toronto, co-discoverer of insulin.

George D. Birkhoff, professor of mathematics at Harvard University, leading contributor to the fundamentals of dynamics.

Reginald A. Daly, professor of geology at Harvard University, authority on the origin of rocks and glaciers.

Edward A. Doisy, professor of biological chemistry at St. Louis University, noted for his identification of pure female hormone and two types of vitamin K.

Ernest W. Goodpasture, professor of pathology at Vanderbilt University, inventor of new methods of studying disease viruses.

Evarts A. Graham, professor of surgery at Washington University, St. Louis, nationally recognized for his contributions to the technique of modern surgery.

Libbie Hyman, member of the American Museum of Natural History in New York, noted for her contributions to the life processes of animals and internationally recognized as an authority on invertebrate zoology.

Herbert S. Jennings, professor emeritus of zoology at the Johns Hopkins University, authority on the behavior of simple forms of animal and plant life.

Karl S. Lashley, professor of neuropsychology at Harvard University, famous for his investigations of brain mechanisms.

Ernest O. Lawrence, professor of physics at the University of California, Nobel Laureate, inventor of the cyclotron, making possible sub-atomic chemistry.

Robert H. Lowie, professor of anthropology at the University of California, authority on the American Indian.

Robert A. Millikan, chairman of the executive council of the California Institute of Technology, Nobel Laureate, measurer of the electron and authority on cosmic rays.

Carlos A. Monge, dean and professor of medicine at the University of San Marcos, Lima, Peru, discoverer of

"Monge's Disease," characteristic of the inhabitants of high altitudes.

Linus C. Pauling, professor and chairman of the department of chemistry at the California Institute of Technology, authority on forces between atoms in molecules and crystals.

Thomas M. Rivers, director of the Hospital of the Rockefeller Institute, international authority on the viruses of human and animal diseases.

Henry N. Russell, director of the Princeton Astronomical Observatory, discoverer of giant and dwarf stars and pioneer in the study of the evolution of the universe.

Florence B. Seibert, associate professor of physiological chemistry at the Henry Phipps Institute, Philadelphia, authority on the chemistry of tuberculin.

Donald D. Van Slyke, member of the Rockefeller Institute, inventor of new methods of chemical analysis used in the treatment of disease.

Oswald Veblen, professor of mathematics at Princeton University, internationally known for his contributions to geometry.

Robert R. Williams, director of chemistry at the Bell Telephone Laboratories in New York, discoverer of vitamin B_1.

SCIENTIFIC NOTES AND NEWS

LEHIGH UNIVERSITY has conferred the honorary degree of doctor of laws on Dr. R. G. D. Richardson, professor of mathematics and dean of the Graduate School of Brown University.

AT the fiftieth anniversary meeting of the Wisconsin Library Association, which was held at Madison on September 26, 27 and 28, Dr. Edward A. Birge, formerly professor of zoology, now president emeritus of the university, was the guest of honor. Dr. Birge is one of the founders of the association. Special tributes to librarians prominent in the history of the association were made during the convention.

DR. JOHN H. LAWRENCE, professor of medicine at the University of California, was presented on September 23 with the medal of the American Roentgen Ray Society at the recent meeting in Cincinnati.

THE Daniel Guggenheim Medal for notable achievements in the advancement of aeronautics has been awarded to Juan T. Trippe, president of the Pan American Airways System, "for the development and successful operation of oceanic air transport." The medal will be presented on January 27 at a dinner to be given by the Institute of Aeronautical Sciences.

THE Theobald Smith Award in the medical sciences of the American Association for the Advancement of Science was presented on September 22 at the Chicago meeting to Dr. Herald R. Cox, of the Rocky Mountain Laboratory at Hamilton, Mont., of the U. S. Health Service. The presentation was made by Dr. Irving Langmuir, president of the association. Dr. Cox spoke on the "Cultivation of Rickettsiae of the Rocky Mountain Spotted Fever, Typhus and Q Fever Groups in the Embryonic Tissues of Developing Chicks."

SAMUEL STACEY, head keeper at the New York Zoological Park, has retired after serving for thirty-seven years with the New York Zoological Society. The title of honorary head keeper of birds has been created for him.

DR. RALPH H. HEEREN has resigned as assistant professor of hygiene and preventive medicine at the State University of Iowa College of Medicine, Iowa City, to accept a similar position at the School of Medicine of Tulane University of Louisiana, at New Orleans.

PROFESSOR BENEDICTO MONTENEGRO, the Brazilian surgeon, has been appointed director of the faculty of medicine of the University of São Paulo.

JAMES RUSSELL OYLER has been appointed General Mills, Inc., research fellow in the department of agricultural and biological chemistry of the Pennsylvania State College. He will work with Dr. H. O. Triebold on the chemical and physical characteristics of certain food fats.

DR. CARL C. LINDEGREN, who has a year's leave of absence from the University of Southern California, is studying the genetics of yeast at Washington University, St. Louis. The work is supported by a grant from Anheuser Busch, Incorporated.

DR. AUSTIN M. PATTERSON, who retired from the professorship of chemistry at Antioch College last June, has joined the staff of Engineering, Science and Management Defense Training of the U. S. Office of Education, as senior specialist in chemical education.

DR. JEROME C. HUNSAKER, head of the department of mechanical engineering at the Massachusetts Institute of Technology, has been appointed a member of the United States Commission which will prepare proposals for the permanent American Aeronautical Commission, created by the Inter-American Technical Aviation Conference at Lima, Peru, in 1937. The permanent commission will attempt to unify and codify the international and national air laws of the American republics.

DR. KARL L. BOWMAN, director of the division of psychiatry at Bellevue Hospital and professor of psychiatry at New York University College of Medicine, has been appointed director of the new Langley

Porter Clinic, a neuropsychiatric unit of the State Department of Institutions, under the direction of the Medical School of the University of California, San Francisco. He will begin his new work at the clinic about November 1. The building, erected at a cost of $500,000, is nearing completion, the cornerstone having been laid on April 5.

DR. RAYMOND L. DITMARS, curator of reptiles and insects at the New York Zoological Park, arrived in New York on September 20 after a visit to Trinidad, bringing with him 1,500 specimens.

SIR HAROLD DELF GILLIES, consultant adviser to the British Ministry of Health, now in charge of special units for the repair of facial injuries in the London area, will be a guest of the American Academy of Ophthalmology and Otolaryngology at the meeting in Chicago, which will be held from October 19 to 23. Sir Harold will make an address at a special defense program presented by the academy on the evening of October 20. The other speakers will be Dr. Irvin Abell, Louisville, Ky., past president of the American Medical Association and now chairman of the committee of the association on medical preparedness as well as chairman of the health and medical committee of the Federal Security Agency; Colonel Louis H. Bauer, Hempstead, N. Y., an authority on aviation medicine and now a member of the committee of the New York State Medical Society on medical preparedness, and Dr. Burt R. Shurly, Detroit, past president of the academy and chairman of its special committee on national defense.

DR. R. D. GILLESPIE, who is now chief psychiatrist for the British Royal Air Force, will visit the United States at the request of the Salmon Committee on Psychiatry and Mental Hygiene of the New York Academy of Medicine. He will deliver the Salmon Memorial Lectures at the New York Academy building on November 17, 18 and 19. He is expected to speak on "Psychoneuroses from the Standpoint of War Experience." The New York lectures will be followed by addresses to be given before the Chicago Neurological Society, the Chicago Institute of Medicine and the Illinois Psychiatric Society in Chicago. Dates for these lectures as well as for lectures in Toronto, Ontario, and San Francisco, Calif., will be announced later.

PROFESSOR WILLIAM LLOYD EVANS, of the Ohio State University, president of the American Chemical Society, spoke before the Ames Section at the Iowa State College on September 24. His topic was "The Chemical Behavior of Reducing Sugars in Alkaline Solution."

DR. ERNEST O. LAWRENCE, professor of physics and director of the Radiation Laboratory of the University of California at Berkeley, will deliver on October 5 the Lower Lecture of the Academy of Medicine at Cleveland. His subject will be "The Newer Physics in Medicine."

PRESIDENT NICHOLAS MURRAY BUTLER spoke at the opening exercises of Columbia University on September 24. He was followed by Dr. Douglas Johnson, professor of physiography and head of the department of geology, who gave the chief address. It was entitled "A Geographer Looks at the World." Dr. Harry S. Mustard, director of the DeLamar Institute of Public Health, was the principal speaker at the opening ceremonies at the College of Physicians and Surgeons.

THE first scientific lecture for 1941–42 of the College of Physicians of Philadelphia was the Alvarenga Prize Lecture, II. It was given on October 1 by Dr. John J. Bittner, assistant director of the Jackson Memorial Laboratory at Bar Harbor, who spoke on "The Influence of Foster Nursing on Experimental Breast Cancer."

IN the special article by E. B. Schoenbach, J. F. Enders and J. H. Mueller on "The Apparent Effect of Tyrothrycin on Streptococcus Hemolyticus in the Rhinopharynx of Carriers," SCIENCE, 1941, 94, 217, the word "tyrothricin" appearing in the title and in the text was misspelled as "tyrothrycin."

THE South West District meeting of the American Institute of Electrical Engineers will be held at St. Louis on October 8, 9 and 10.

THE one hundred and twenty-first annual meeting of the Swiss Society for the Investigation of Nature was held at Basle from September 6 to 8.

IT is planned to hold an Inter-American Chemical Congress at Santiago, Chile, in January, 1942.

THE Société de Biologie de Montréal has announced the publication of a review which will be its official organ and which will contain the proceedings of the society as well as other reports of research. The membership of the society includes physicians, physiologists, biochemists, pharmacologists, bacteriologists, zoologists and others. The *Revue canadienne de Biologie,* which will be published in French, will appear under the auspices of the Université de Montréal. The society held its first meeting of the year on September 17 in the laboratory of physiology at the university.

THE Civil Service Commission announces an examination for radio mechanic-technicians at salaries ranging from $1,440 to $2,300 a year. Applications must be received by November 6. Applicants must show that they have had appropriate training or ex-

perience in one or more of the following: Paid experience in technical radio work such as radio repairman, operator or electrician; technical study in residence at a radio school; resident study including courses in radio in a school of engineering or technology; completion of an approved defense training course in any branch of radio work. An announcement by the commission states that the constantly increasing activities of the Navy Department call for many inspectors of aeronautical engineering materials. For many months the commission has had open an examination for inspectors covering several branches of aeronautical engineering materials. Provisions for using national defense training courses to meet the experience requirements have been liberalized. The positions pay from $1,620 to $2,600 a year, and the maximum age is 65 years.

THE New York Academy of Medicine announces the availability of the Louis Livingston Seamon Fund for the furtherance of research in bacteriology and sanitary science. Two thousand dollars is available for assignment in 1941. The fund will be expended only in grants in aid for investigation or for scholarships for research in bacteriology or sanitary science. Grants may be used for technical help, for aid in publishing original work or for the purchase of necessary books or apparatus. The fund is administered by a Committee of the academy under the following conditions and regulations: Communications should be received before November 1 by Dr. Wilson G. Smillie, chairman of the Louis Livingston Seaman Fund, 1300 York Avenue, New York City.

THE Louise A. Boyd Arctic Expedition of the National Bureau of Standards, which sailed from Washington on June 11, is expected to return about November 1. Both Miss Boyd and Captain Bob Bartlett, who commands the expedition schooner *Effie M. Morrissey,* are Arctic explorers of wide experience. They planned to observe the ionosphere characteristics as determined by special radio measurements, geomagnetism, auroral manifestations and also to measure ultraviolet light intensities. The expedition, under the leadership of Dr. Louise A. Boyd, was undertaken at the request of the Government, Dr. Boyd having been appointed a consulting expert of the National Bureau of Standards. The U. S. Coast Guard and the Department of Terrestrial Magnetism of the Carnegie Institution cooperated in the arrangements for the expedition.

AT a dinner of the citizens of Chicago on September 26 at which the attendance was 800, it was reported that $9,200,000 had been subscribed to the fiftieth anniversary fund of $12,000,000 of the University of Chicago. It is planned to raise the balance of the money over a period of five years.

THE Congress of the United States on September 15, as reported in the *Journal* of the American Medical Association, completed legislative action on a bill authorizing the War Department to purchase for $1,000,000 a site near the Folger Shakespearean Library for the new Army Medical Library and Museum to cost $3,750,000.

THE School of Medicine and Dentistry of the University of Rochester received more than $900,000 last year through the will of Dr. Henry C. Buswell. It will now receive the same amount under the will of his wife, Mrs. Bertha H. Buswell. Mrs. Buswell died on July 30. Her will makes available ultimately to the Medical School a trust fund of $925,164.

A LARGE collection of cactus plants, a gift of Mexico to the United States, was taken to the New York Botanical Garden on September 1 after a two months' display at Rockefeller Center, to be made a permanent part of the cactus collection. The gift was officially accepted last July by Dr. William J. Robbins, director of the garden.

DISCUSSION

THE EFFECTIVENESS OF EQUIMOLAR QUANTITIES OF VARIOUS CARDIAC GLYCOSIDES

IT has recently been re-emphasized[1] that the human therapeutic doses of the several pure cardiac glycosides are not predictable from animal toxicity assays. It has, apparently, not been pointed out that in the cases of certain comparable glycosides for which the single dose, or short-time interval multiple intravenous dose, for "full digitalization" in auricular fibrillation is known, there is remarkably small difference in the molar quantities of the drugs necessary to produce comparable effects. Furthermore, in at least one glycoside differing from others in the chemical configuration at the C_3 position the molar quantities of drug necessary to produce comparable therapeutic effects are widely different.

In the accompanying Table I are shown the intravenous "full digitalizing doses" for auricular fibrillation, together with cat lethal assay figures and certain chemical data for five pure glycosides and one mixture. It will be noted that, for the first four sub-

[1] H. Gold and McK. Cattell, SCIENCE, 93: 197, 1941.

stances listed, the full therapeutic doses expressed in micromols are of similar magnitude. The agreement is better than that obtained if animal lethal potencies are compared. In these four glycosides the hydroxyl at C_3 in the nucleus has the α configuration. Fieser[9] has pointed out certain correlations between physiological activity measured by toxicity and the configuration at the C_3 position.

TABLE I

Glycoside	Molecular weight	Intravenous digitalizing dose for man: mg	Intravenous digitalizing dose for man: micromols†	Cat lethal micromols*	Configuration C_3	Sugar
Ouabain	584	1.0[2]	1.7	0.21	α–OH	Rhamnose
Digitoxin	764	1.2[3]	1.6	0.43	α–OH	Digitoxose
Lanatoside C	984	1.5[4]	1.5	0.22	α–OH	Digitoxose
Digoxin	780	1.0[5]	1.3	0.28	α–OH	Digitoxose
		1.5[6]	1.9			
Thevetin	858	4.2[7]	4.9	1.06	β–OH	Digitalose?
Scillaren A and B	692	0.5[8]	0.7	0.22	no–OH?	Rhamnose
		0.7	1.0			

* The correction for water of crystallization has been neglected in these calculations. The value is unknown for the materials used by the several investigators. If the proper correction could be applied the molar dosages would be smaller, the largest correction probably being for ouabain.

In the case of thevetin the human intravenous dose in question is about three times as great as in the first four on a molar basis. In this glycoside the hydroxyl at C_3 has the β position.

On the basis of one report on the use of a mixture of Scillarens A and B a somewhat lower effective dose is indicated. The structures of Scillarens A and B have not been satisfactorily investigated, but absence of the hydroxyl at C_3 has been reported.

The comparable full therapeutic doses for the glycosides ouabain, digitoxin, lanatoside C and thevetin are satisfactorily established. In the cases of the other glycosides less extensive studies have been made. Moreover, it must be pointed out that the criterion of effectiveness in studies on rapid digitalization in auricular fibrillation is an arbitrary one, namely, a reduction in pulse rate, usually to 80 per minute or below, within a specified time. Although it has frequently been so assumed, there is no satisfactory proof that this initial slowing of the pulse is due entirely or majorly to an effect upon the heart directly. In fact, since it is largely abolished by atropin, the early slowing is probably not due to a primary action on the heart, but rather to one upon the nervous cardioregulatory mechanism. Cushny[10] showed that the early rate changes in digitalization in auricular fibrillation are mediated by vagal influences.

It is by no means certain that the approximate identity of molar doses for full digitalization in fibrillation reported for the first four glycosides in Table I would be found if other criteria were employed. The lack of corresponding agreement in cat lethal doses points to such differences in regard to certain actions at least.

It may be noted that there is no apparent correlation between the nature of the sugar in the glycoside and the physiological action in question.

Attention is being called to the remarkable coincidence of human intravenous doses of several pure glycosides for a particular effect, not so much because it is believed that the configurational peculiarity referred to is more important than others may be found to be, particularly if other criteria of effectiveness are studied, but rather to emphasize the possibility and desirability of further studies in the direction of correlation of action with structure.

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[2] J. Wyckoff and W. Goldring, *Arch. Int. Med.*, 39: 466, 1927.

[3] H. Gold, N. Kwit and McK. Cattell, *Jour. Pharmacol. and Therap.*, 69: 177, 1940.

[4] N. Kwit, H. Gold and McK. Cattell, *Jour. Pharmacol. and Therap.*, 70: 254, 1940.

[5] Medical Research Council of the British Medical Association.

[6] E. Schwab, *Texas State Jour. Med.*, 35: 619, 1940.

[7] H. Arnold, W. Middleton and K. Chen, *Am. Jour. Med. Sci.*, 189: 193, 1935.

[8] L. Zwillinger, Wien, *Arch. f. inn. Med.*, 31: 201, 1937.

[9] L. F. Fieser, "The Chemistry of Natural Products Related to Phenanthrene," Reinhold, New York, 1937.

A NOTE ON SZENT-GYORGYI'S "TOWARD A NEW BIOCHEMISTRY"

IN his recent paper[1] Professor Szent-Györgyi advances the hypothesis that a quantum of energy, made available at one point in a living system by chemical action or absorption of light, for example, may be transmitted to a relatively distant point of the system without degradation or dispersion, there to cause some highly localized reaction, such as photosynthesis or the splitting of a protein. The examples cited by Professor Szent-Györgyi prove, of themselves, that this brilliant hypothesis must be considered in any future biochemical or biophysical speculation.

Professor Szent-Györgyi postulates, in his paper, that the mechanism whereby this energy is transmitted is that which has proved effective in fluorescent crystals of ZnS and other substances, the excitation of an electron to an unfilled extended state "belonging" to the entire structure rather than to one or two atoms. To the present writers, this second postulate would appear to limit seriously the generality of the original

[10] A. Cushny, "The Action and Uses of Digitalis and Its Allies," Longmans, Green and Co., London, 1925.

[1] SCIENCE, 93: 609, 1941.

hypothesis, without bringing any compensatory advantages. As a matter of fact, the whole chemical and physical behavior of proteins and other biochemical substances would suggest a Van der Waals' binding, which does not have extended electron states, rather than the electron band binding typical of salt or the diamond. There are other mechanisms already well known to which appeal may be made.

It is well known that neutral or excited atoms, molecules or free radicals may be adsorbed on solid or liquid surfaces as a mobile two-dimensional gas. Such excited mobile entities constitute a second possible mechanism for the effects which Professor Szent-Györgyi discusses. Others are known, and it would be a daring biologist who would suggest that there are no more undiscovered mechanisms.

To summarize, this note suggests that Professor Szent-Györgyi's hypothesis may be of greater use to biology if it is left in its simplest and most general form, "There exists *a* mechanism which permits the energy of absorbed light or chemical reaction provided in one portion of a living system to be available, without degradation or dispersion, for chemical reactions in relatively distant portions of the system," without tying to any particular mechanism or even to any known mechanism, until much more information is available.

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ONE SOURCE OF CLAY BALLS

THE Smoky Hill River has a variable flow like all the streams of Western Kansas. Commonly it occupies only part of its channel. During high water and its recession much mud is plastered on the banks and bars. During the succeeding low-water stages mud cracks develop in this layer, often penetrating to considerable depth. As the mud dries further the layers become separated. The oblong, flattened chunks of dried mud which result from the cracking and separation of layers are later washed or otherwise tumbled into the stream.

The mud, having been water-laid in that fashion, is of finely divided clay particles, giving a uniform clay which is quite plastic when wet. I have molded bits of this mud and fired them. The chunks which fall into the stream cohere during transport and are rounded by rolling along the stream bed. Some of them are shunted out of the current and come to rest among the pebbles and sand on the shoals and bars, where they may be further rolled, accumulating an armor of sand and pebbles, or they may be buried among the other sediments in the stream bed.

All stages of this process have been observed. My interest was first aroused by finding some isolated clay masses in the sand on the bank of the stream south of Gorham, Kansas. Knowing that the available clays along the course of the stream west of this point are quite limy, I looked for a source of more plastic clay such as in these masses. The stages of development were found just east of Highway U. S. 183 near Schoenchen, Kansas.

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A FLORIDA WHITE BLACKBERRY

THE author recently discovered a large wild colony of a white-fruited blackberry near Gainesville, Florida, and has named it *Rubus cuneifolius* Pursh, forma *albifructus*. The plants closely resemble those of the species and the fruits differ chiefly in lacking the black color. Experiments will be undertaken to determine the origin of this form and to improve it, if possible, for local use. The white blackberries at present offered for sale are not suited to the Florida climate.

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AN ANALYSIS OF THE MAJOR INTERESTS OF THE MEMBERS OF THE BOTANICAL SOCIETY OF AMERICA

THE recently published Year Book (1940–41) of the Botanical Society of America[1] includes a list of members with their addresses and major fields of interest. A study was made of the latter to determine the distribution of interests among the various botanical subsciences. Table 1 presents the results of this analysis. It will be noted that approximately one half of the total "interests," *i.e.*, 948, lie in the morphological sciences. The low percentages of women interested in the fields of plant pathology (6 per cent.), plant geography (3 per cent.), economic botany (6 per cent.) and phylogeny (0 per cent.) are noteworthy.

It should be emphasized that the figures in the table do not indicate numbers of individuals in the various divisions of plant science, for many of the botanists listed in the Year Book have given several fields of interest. Therefore, this table is a summary of *interests*, not *individuals*. Accordingly, the fact that the total number of "interests" listed in the table is 1,829, whereas there are but 1,365 members in the society, should occasion no surprise. It should also be pointed out that this table gives but a partial picture of the "interests" of American botanists, for many plant scientists are not members of this society but may be affiliated with various special organizations, such as

[1] Miscellaneous Series, Publication 124, January, 1941, Office of the Secretary, New Haven, Conn.

the American Phytopathological Society, the American Society of Plant Physiologists, the Ecological Society of America, the American Society of Plant Taxonomists, the Genetics Society of America, the Mycological Society of America and numerous other organizations. For example, the American Phytopathological Society has a membership of 1,128; the American Society of Plant Physiologists, 623; the American Society of Plant Taxonomists, 514; and the Mycological Society of America, 384.

TABLE 1

Sub-science	"Interests" of men	"Interests" of women	Total	Per cent. of women
Systematic botany	199	34	233	15 per cent.
Morphology	165	54	219	25 " "
Cytology	124	32	156	21 " "
Mycology	107	22	129	17 " "
Anatomy	79	26	105	25 " "
Algology	30	9	39	23 " "
Paleobotany	31	4	35	12 " "
Bryology	17	7	24	29 " "
Phylogeny	8	0	8	0 " "
Total of morphological sub-sciences	760	188	948	20 " "
Physiology	349	57	406	14 " "
Pathology	143	9	152	6 " "
Ecology	122	17	139	12 " "
Genetics	100	20	120	17 " "
Plant Geography	32	1	33	3 " "
Economic Botany	29	2	31	6 " "
Grand Total	1,535	294	1,829	

Table 1 does not include some of the minor subdivisions listed in the Year Book, such as kryobiology, atmometry and micrurgy. One botanist gives as her interests—"pathology; morphology; peanuts."

The five universities with the largest numbers of members are Cornell with 37, California (Berkeley) with 35, Harvard with 33, Wisconsin with 25 and Illinois with 22. Thirty-five members are listed from the U. S. Department of Agriculture in Washington.

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SCIENTIFIC BOOKS

PHYSICAL CHEMISTRY

Physical Chemistry, A Brief Course. By LOUIS J. BIRCHER, Ph.D., professor of physical chemistry, Vanderbilt University. xvi + 429 pp. Prentice-Hall Chemistry Series, Wendell M. Latimer, Ph.D., editor. New York. 1940.

THE preface states:

> The value of specific training in theoretical or physical chemistry is being recognized not only for students who are majoring in chemistry and chemical engineering, but also for those who are preparing for medicine, biology, geology, agriculture, and other branches of engineering. . . . In an effort to meet the needs of students who can profit by a brief course in physical chemistry taken in the intermediate college years, certain materials which seem particularly useful have been selected from the larger field of theoretical chemistry. . . . This material and certain other topics that are included should serve as a background for advanced work in chemistry or for those other sciences in which chemistry plays an important part.

"Each part of the book stresses a phase of the problems of solubility and reactivity." Part I (pp. 3–108) deals with the role played by atomic and molecular structure; Part II (pp. 109–220), transitions from state to state and fugacity as a controlling factor in chemical reactivity; Part III (221–358), physico-chemical change, reaction velocities and the methods of measuring reactivity; Part IV (359–420), directions for 12 laboratory experiments.

Simple proportion and the natural logarithm constitute the mathematics necessary for understanding the equations in this book. Most of the subject matter is to be found to-day in the better type of college texts on inorganic, qualitative and quantitative analysis. The merit of the book consists in the organization of this material in one volume for those students of agriculture, biology and medicine who do not have the preparation for a standard course in physical chemistry for which a knowledge of elementary calculus is prerequisite. For this group of students the book can be recommended as a readable and appropriate text.

However, if the book is addressed to students of chemistry, chemical and other branches of engineering, it should be pointed out that the American Chemical Society's committee has recently taken the position that they do not recognize a course in physical chemistry which does not require the use of the calculus as meeting their requirements for accrediting a school.

The use of fugacities is properly emphasized as "more exact measures of reactivity," but it is questionable if fugacity merits the space assigned when more immediately practicable concepts for the students addressed are necessarily dismissed with elementary statements and problems.

The distinction between reactivity and rate of reaction is not clear. This is evident from the highly plausible, but nevertheless incorrect statement (p. 226): *"The number of collisions between the molecules involved in a chemical reaction is proportional to the product of the active masses (activities), a,* or often, less accurately, the partial pressures or concentrations of the several reacting substances. (Italics mine.)

On pages 226–227, this "generalized" treatment leads to equations for the velocity of a reaction as proportional to the product of activities! Later in the

chapter on reaction velocity (p. 343), these equations are referred to, but become, without explanation, the products of concentrations. Nothing is said about the critical complex or the importance of activities and their coefficients at a point where they are of the greatest importance. It has been repeatedly emphasized in the American literature for the past fifteen years that if the italicized statement and the equations (p. 226–227) were correct, there could be only negative salt catalysis and never positive salt catalysis in contradiction to well established experimental evidence.

The author is to be commended for introducing the concept of osmotic coefficient. This innovation, for an elementary book, will save the student from unlearning later erroneous statements about ionic dissociations.

Unfortunately, however, after all the preparation on fugacity, activity of the electrode (p. 273) and of the ions, (p. 268), one learns (p. 274), that "hydrogen ion concentration is the most exact measure of the 'acidity' of a solution." The student is given no inkling that pH really involves the activity and not the concentration of hydrogen ion.

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KINETIC THEORY OF GASES

An Introduction to the Kinetic Theory of Gases. By SIR JAMES JEANS, O.M., F.R.S. 311 pp. New York: The Macmillan Company; Cambridge University Press. 1940. $3.50.

THIS book lies somewhere between a treatise such as represented by the author's "The Dynamical Theory of Gases" and a text-book for advanced students. It is, in fact, the author's intention to supply a book which will provide such knowledge of the kinetic theory as is required by the average serious student of physics and physical chemistry, and at the same time give the mathematical student the equipment he should have before undertaking the study of specialist monographs.

The book differs from the author's larger work above cited in that the subject is covered in a more elementary manner, with less mathematical rigidity and with greater attention to the physical and descriptive aspects. The various concepts are illuminated, moreover, to an extent unusual in a book of this kind, by the inclusion of accounts of experimental investigations.

The book covers a wide field, and it is inevitable that there should be a considerable range of difficulty in the various parts. It is probable that the student who has already an acquaintance with the subject will get more benefit from the work than will a beginner; and to the semi-advanced student the book will constitute a valuable reference to which he may turn to refresh his memory when the practical need occurs for drawing upon various parts of the subject.

The work is rich in references both on the experimental and theoretical sides. It contains much useful numerical material and a helpful appendix, containing certain special standard theorems and also tables convenient for numerical calculations associated with the subject.

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SPECIAL ARTICLES

ISOLATION OF THE VIRUSES OF WESTERN EQUINE AND ST. LOUIS ENCEPHALITIS FROM *CULEX TARSALIS* MOSQUITOES[1]

IN North America three types of epidemic virus encephalitis are recognized. Two of these,.the eastern and western types of equine encephalomyelitis, are believed to be mosquito-borne. Mosquito transmission has been repeatedly demonstrated in the laboratory (summarized by Davis[2]), but until now the virus has never been isolated from mosquitoes collected in epidemic areas. With respect to the St. Louis encephalitis virus opinions of observers have differed as to the mode of transmission. Lumsden[3] concluded that it was probably transmitted by Culex mosquitoes. Mitamura and associates[4] have reported successful transmission of this virus in the laboratory by *Culex pipiens.*

In the Yakima Valley, Washington, evidence was obtained by Hammon[5] and Hammon and Howitt[6] during the summer of 1940 indicating the probable presence in man and horses of both the western equine

[1] Part of a Cooperative Survey of Encephalitis in the Yakima Valley by the University of California, the State College of Washington, the Washington State Health Department, the Yakima City-County Health Department and the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine. Aided by a grant from the Natural Foundation for Infantile Paralysis, Inc.

[2] W. A. Davis, *Amer. Jour. Hygiene,* 32: 45, 1940.

[3] L. L. Lumsden, Unpublished official report, 1933.

[4] T. Mitamura, S. Yamada, H. Hazato, K. Mori, T. Hosoi, M. Kitaoka, S. Watanabe, K. Okubo and S. Tenjin, *Tr. Jap. Path. Soc.,* 27: 573, 1937.

[5] W. McD. Hammon, *Jour. Am. Med. Assn.,* 117: 161, 1941.

[6] W. McD. Hammon and B. F. Howitt, To be published.

irus and the St. Louis virus. These workers outlined vidence which suggested a Culex mosquito as the kely vector for the latter. In May of 1941 an exnsive, coordinated field and laboratory survey of this gion was begun. This preliminary report deals with e isolation of both the St. Louis and the western uine viruses from *Culex tarsalis* taken in routine tomological collections where human encephalitis ses occurred during this or the previous year. These llections were planned with the purpose of finding, possible, either or both of the encephalitic viruses lieved to be present in the region. The same sury, by serum neutralization tests of birds and mamals, indicated probable wide-spread infection by both Hammon, Gray, Evans, Izumi and Lundy[7]).

Live arthropod specimens were collected by means specially constructed light traps, sweepings and nd collections. These arthropods, after identificaon in the field laboratory under light chloroform nesthesia, were sealed in hard glass shell vials by rawing in a gas-oxygen flame. They were then rozen, stored and shipped in CO_2 ice to the San rancisco Laboratory. Here, in lots of a single spes containing from 5 to 150 specimens, the arthrods were washed in saline, then ground in a mortar ith alundum in 3.0 ml of 30 per cent. sheep serumline. The supernatant, after 10 minutes centrifugaon at 16,000 r.p.m. in an International Centrifuge ultispeed Head, was cultured and 5 Swiss mice, ockefeller strain, inoculated with .03 ml intracereally. All mice were observed for 21 days. Several ts of *Aedes campestris* were infected with the westn equine virus in the field laboratory and served controls for the method of shipping and handling r virus isolation.

From the arthropod material collected this season 503 specimens have been tested for the presence of rus. This includes 7,619 mosquitoes,[8] 1,458 specens of other flies[9] and 426 miscellaneous biting thropods. Of these arthropods, *C. tarsalis,* of which 293 specimens have been tested, is the only one to te from which a virus has been isolated. From a ol of 66 mosquitoes (Pool No. 103 collected July h) the St. Louis virus was isolated, and from a pool 125 (Pool No. 116 collected July 15th) the western uine virus was recovered.*

[7] W. McD. Hammon, J. Gray, Jr., F. C. Evans, E. M. umi and H. W. Lundy, *Science,* 94: 2439, 1941.

[8] *Anopheles maculipennis freeborni, Theobaldia inorta, Theobaldia incidens, Aedes vexans, Aedes dorsalis, edes campestris, Aedes nigromaculis, Aedes increpitus, edes cinereus, Aedes lateralis, Culex tarsalis, Culex piens.*

[9] Simuliidae (black flies), Tabanidae (horse flies), nscidae (house flies, horn flies and stable flies).

* Since this paper was written 2 other viruses have been olated from lots of *C. tarsalis.* These have not yet been entified.

Isolation of St. Louis Virus

Among five mice inoculated with Pool No. 103 two were found in convulsions 8 days after inoculation. These were sacrificed and their brains were found to be bacteriologically sterile. Each brain was passed separately to 3 other mice by intracerebral inoculation of a 10 per cent. suspension. These came down with encephalitic symptoms or were found dead between the 4th and the 6th day. After the virus was well established in mice, steps were taken to identify it. It was found to pass through both N and V Berkefeld filters. It produced no symptoms after intracerebral inoculation in two guinea pigs, a rabbit, a monkey (*Macacus rhesus*) and a lamb. A fatal infection was produced in mice by intranasal inoculation and by intraperitoneal inoculation of over 100,000 fatal intracerebral doses. No symptoms were produced when a similar dose was given subcutaneously. These tests were sufficient to tentatively identify the virus as that of St. Louis encephalitis.

A neutralization test was set up against normal rabbit serum, hyperimmune western equine guinea pig serum and hyperimmune St. Louis rabbit serum. At the same time the St. Louis serum was titrated against a known strain of St. Louis virus. Both the "Culex 103 virus" and the St. Louis virus were neutralized to the same degree by the hyperimmune St. Louis serum. The western equine serum afforded no protection. It appears from these findings that the virus isolated from this pool of *C. tarsalis* is that of St. Louis encephalitis.

Isolation of Western Equine Virus

Among mice inoculated with Pool No. 116 one was observed in rolling convulsions 6 days after inoculation. It was sacrificed, and after the brain was found to be bacteriologically sterile it was passed by intracerebral inoculation to four other mice. On the fourth day the first of these showed suspicious signs of illness and brain passage was made to 2 guinea pigs and 4 mice. The guinea pigs developed high temperatures on the third day. One died 24 hours later and the other was sacrificed on the fifth day. Neither guinea pig was paralyzed or noted to have convulsions. Subsequent passages in guinea pigs resulted regularly in paralyses of the hind quarters and abdominal muscles, and running convulsions typical of equine encephalomyelitis. The pathogenic agent was found to pass through both Berkefeld V and N filters. Although adaptation to guinea pigs was easily accomplished, the virus was not readily adapted to mice.

Experiments were done to determine if the virus were that of western equine encephalomyelitis. In one instance a normal guinea pig and one previously immunized to the western equine virus were inoculated

intracerebrally with a 10 per cent. suspension of the brain of a guinea pig infected with the "Culex 116 virus." The normal guinea pig succumbed in the course of a typical encephalitic infection, but the immune animal remained normal. In the next experiment two normals and two hyperimmune controls were used and similar results obtained. It appears therefore that the virus obtained from this pool of *C. tarsalis* is that of western equine encephalomyelitis.

Experiments are now in progress to test the ability of *C. tarsalis* to serve as a host to, and to transmit these viruses. Already *C. tarsalis* has been fed on a guinea pig infected with the western equine virus and the virus readily demonstrated after 5 days incubation. Until actual transmission of one or both of these viruses has been demonstrated the role of this mosquito as a vector is not proven. These findings have, however, increased the evidence incriminating mosquitoes as vectors of these encephalitic virus diseases.

ADDENDA

Culex tarsalis is a North American species distributed throughout the states west of the Mississippi River. In the Yakima Valley it is the most common mosquito, and its larvae are found in many types of water: permanent ponds, irrigation seepage, barnyard drainage and sewage. Adults were taken in all areas where light traps were run, and were collected in large numbers in shelters such as barns and houses. In all areas of the Valley where encephalitis occurred in man or horses it was collected in significant numbers. It is more abundant than *Culex pipiens,* the other common Culecine of this area. In temperate regions adult females are reported to hibernate in sheltered places, emerging in the spring to commence egg laying (Hearle.)[10]

The feeding habits of *C. tarsalis* have not been extensively studied. Direct observations made in the Yakima Valley indicate that it feeds on man, horses, mules, cows and mallard ducks. Other workers have indicated that it feeds on avian blood (Freeborn)[11] and on man (Hearle)[10].

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[10] E. Hearle, *Nat. Res. Council Rept.* 17, Ottawa, Canada, 1926.

[11] S. B. Freeborn, *Univ. of Calif. Publ. Tech. Bull. Entom.,* Bull. III, 5: 333, 1926.

DIAGNOSIS OF EPIDEMIC ENCEPHALITIS BY COMPLEMENT-FIXATION TEST

DURING the months of August and September, 194 encephalitis in man occurred in epidemic form i Manitoba, Canada, and central United States. Blo sera from patients were dispatched to the Rockefell Institute for diagnosis.[1]

Complement-fixation tests were carried out on ea serum against the antigens of Western equine e cephalomyelitis, Eastern equine encephalomyeliti lymphocytic choriomeningitis and St. Louis encephali tis. The sera were inactivated at 60° or 65° C. a tested both undiluted and in twofold dilutions throu 1:16 according to the method we have previously d scribed.[2]

Of thirty-six sera from Manitoba, twenty-two ga a strong and completely specific reaction with t Western equine encephalomyelitis antigen; of eig sera from Colorado, two exhibited a similarly stro specific reaction. The titres of the positive sera, determined by the highest dilution of serum giving 2+ or better reaction, were 1:4 in four cases, 1:8 three cases and 1:16 or 1:16+ in seventeen cases.

Of nine sera drawn from patients within 10 da or less after onset of illness, none was positiv whereas of thirty-five sera drawn from patients 11 30 days after onset, twenty-four or 69 per ce proved positive.

Two samples of serum were obtained from each two cases in Colorado, and they are of special interes The first samples from each patient, taken a few da after onset of illness, were negative, whereas t second samples, taken during the second week of i ness, gave a strongly specific reaction with Weste equine encephalomyelitis antigen.[3]

The above tests indicate that the present epidem of encephalitis in Manitoba and central United Stat is caused by the Western equine encephalomyeliti virus and demonstrate the value of the complemen fixation test as a practical and speedy diagnost tool.

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[1] Sera and brain tissue specimens were kindly sent by Dr. Daniel Nicholson, Winnipeg, Canada; Captain E. G. Gould, Camp Shilo, Manitoba; Lieutenant S. Youn Brandon, Manitoba, and Dr. J. E. Smadel, New York.

[2] J. Casals and R. Palacios, SCIENCE, 93: 162, 194 *Jour. Exp. Med.* (in press), October, 1941.

[3] From the brain tissue of one fatal case of encephaliti in Winnipeg a virus was obtained by inoculation in W-Swiss mice. An antigen was prepared from this viru containing brain tissue, which fixed complement sp cifically with known Western equine encephalomyeliti immune serum. Neutralization and protection tests co firmed this result.

LUORESCENCE OF HARDERIAN GLANDS IN MICE OF CANCER-SUSCEPTIBLE AND CANCER-RESISTANT STRAINS[1]

IN the course of routine examination of mice under ra-violet light (G.E. B-H4) it was discovered that ere was a great variation in red fluorescence in the posed Harderian glands of mice of the various ains. The degree of variability may be expressed the symbols 0, +, ++, +++, ++++. The two extreme iants were found in adult mice beyond 300 days life of the JK cancer-resistant strain (0 – +) and ce of the C_3H strain cancer-susceptible (+++ – ++++). ice of the inbred strains have shown, so far, a fair gree of constancy, whereas, mice of the NH descent, ich are relatively heterozygous (F_5–F_8 generations presented) have shown marked individual variability red fluorescence of the Harderian glands. An age iation was also observed. Before the eyes were en at 14 days, no fluorescence of orbital contents was tected. In early sexual maturity a high fluorescence s seen. This was found to decrease in intensity in mice with advancing age and was completely ab- t in old mice. This decrease in fluorescence with vancing age was not observed in C_3H mice.

Red fluorescence of the Harderian gland is an indi- ion of the presence of porphyrins (Graflin,[2] Der- n and Turchini[3]). Little is known regarding por- yrins within the body. There is, however, some evi- nce to indicate that they may be involved in the syn- sis or destruction of hemoglobin (Lemberg,[4] Hill d Keilin[5]). Biliverdin results from the oxidative itting or opening of the porphyrin nucleus of haemochromogen in the liver (Lemberg[4]). It was found by Strong and Werner[6] that there was a precocious drop in the hemoglobin level in a mouse of the C_3H strain as compared with one of the JK strain. A similar finding was reported by Strong and Francis[7] in mice of the A (cancer-susceptible) and CBA (partially cancer-resistant) strains. Strong[8] suggested that this precocious drop was due to one of two possibilities; (1) that hemoglobin was being produced at a rate lower than normal, or (2) that it was being destroyed at an abnormally high rate. Porphyrins are also known to be important constituent parts of catalase (Zeile[9, 10] and Stern[11]) the Pasteur enzyme (Stern and Melnick[12]) and cytochrome c (Hill and Keilin[5]).

Thus it is clear that the present observation may be of interest in the investigation of at least two problems: (1) A genetic analysis of the occurrence and transmission of such a variant, and (2) the investigation of various physiological states as influenced by the presence, absence or abundance of such a chemical within the body. Since mice of the JK and C_3H strains show the maximum degree of difference to both cancer susceptibility and porphyrins in the Harderian gland, such an investigation should include a search for a possible relationship between porphyrins and some physiological process that may be correlated with carcinoma susceptibility.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A NEW DIGESTION TUBE

THE chemist is often faced with the problem of ving to determine accurately, by means of acid gestion, small quantities of protein. During diges- n, these protein solutions may bump and foam. e possible loss of material by bumping may usually controlled by good technique. Occasionally, how- r, with the most careful technique, loss of material y invalidate the entire procedure.

Certain types of determinations can be effected by the use of the N.P.N. tube and the Kjeldahl flask, to mention but two of the several digestion tubes and flasks available to chemists. Few of the methods involving the use of the N.P.N. tube are accurate.

[1] This investigation was aided by grants from The Jane lin Childs Memorial Fund for Medical Research and e Anna Fuller Fund.

[2] A. I. Graflin, *Anat. Rec.*, 79: suppl. 25, 1941 (abet).

[3] E. Derrien and J. Turchini, *Compte rend. Soc. de Biol.*, 1028–29, 1925.

[4] R. Lemberg, *Biochem. Jour.*, 29: 1322, 1935.

[5] R. Hill and D. Keilin, *Proc. Roy. Soc. London*, 107: 286–92, 1930.

[6] L. C. Strong and T. H. Werner, *Am. Jour. Cancer*, 26: 767–69, 1936; 27: 115–19, 1936.

[7] L. C. Strong and L. D. Francis, *Arch. Path.*, 23: 202–06, 1937.

[8] L. C. Strong, *Am. Jour. Cancer*, 27: 500–09, 1936.

[9] K. Zeile and H. Hellström, *Hoppe-Seyler's Zeits, für Phys. Chem.*, 192: 171–92, 1930.

[10] K. Zeile, *Hoppe-Seyler's Zeits. für Phys. Chem.*, 195: 39–48, 1931.

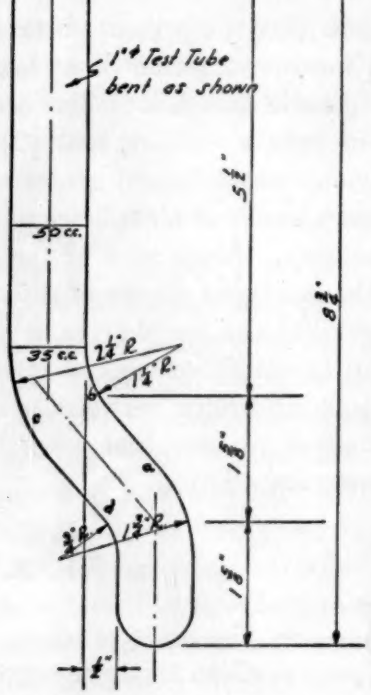
[11] K. G. Stern, *Jour. Biol. Chem.*, 112: 661–, 1936.

[12] K. G. Stern and J. L. Melnick, *Jour. Biol. Chem.*, 139: 301–23, 1941.

[13] Rockefeller Foundation fellow at Yale University, 1940–41.

This is especially true of the protein determination of cerebrospinal fluid, a process associated with so much foaming and bumping that, for clinical purposes, the results are often not as acceptable as they should be. The Kjeldahl method is exact, but its use necessitates a nitrogen distillation system and accurate burettes for back-titrations. The apparatus is expensive and the technique time-consuming.

We have designed and constructed a new digestion tube by means of which the loss of material due to foaming and bumping can be eliminated. The tube



DIGESTION TUBE
FIG. 1

is designed so that a drop of boiling solution can not be shot directly outwards. When thrown upwards, it must necessarily strike the wall of the tube along the lines "a" and "b" and flow back into the solution. Foam also will rise up between the points "a" and "b" and descend by points "c" and "d." Seldom does it rise beyond the point "b."

By the use of the tube described, the more difficult types of digestion can be performed with ease and accuracy. There is no loss of solution and much saving of time. The most ordinary technique will furnish exact results. The new digestion tube is especially suitable for those methods for which the N.P.N. tube is, at present, used.

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A TECHNIQUE FOR CONTINUOUS OR INTERMITTENT OBSERVATION OF THE CONTRACTILE VACUOLES OF PARAMECIUM

THE methods commonly used for demonstrating and studying the contractile vacuoles of Paramecium have the serious disadvantage of not permitting the observer to view the animals intermittently over a period of several days. In the technique described below continuous observation is made possible by studying the animals on the surfaces of agar plates.

PREPARATION AND USE OF THE AGAR PLATES

Filter 1,000 cc of culture medium which has supported a vigorous growth of Paramecium through coarse filter paper. The medium should be clear and transparent. Bring the filtrate to a boil and add, while stirring, 10 gms of agar-agar. Boil slowly until all the agar is dissolved. The agar is then poured, while hot, into Syracuse watch glasses to a depth of approximately 5 mm. The agar is then allowed to cool, without agitation, until it is firmly set.

When the agar is set, one drop of a rich culture of Paramecium is placed in the center of the dish, which is then tilted from side to side to spread the drop. Within a few minutes enough water has evaporated from the surface to impede locomotion. The animals may then be studied at leisure.

For prolonged observation of the same preparation it is necessary to prevent undue evaporation from the surface of the agar. This is best accomplished by inverting the dish over another watch glass partly filled with water. In this way we have kept and observed animals in the same preparation for as long as ten days. Temporary preparations may be made with distilled water, but the animals do not survive on the surface of agar so prepared.

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